

Data Visualization Collection. How graphical representation can inspect and communicate sustainability through systemic design.

*Original*

Data Visualization Collection. How graphical representation can inspect and communicate sustainability through systemic design / Stabellini, Barbara; Remondino, CHIARA LORENZA; Tamborrini, PAOLO MARCO. - In: THE DESIGN JOURNAL. - ISSN 1756-3062. - ELETTRONICO. - 20:(2017), pp. 1673-1681. [10.1080/14606925.2017.1352690]

*Availability:*

This version is available at: 11583/2679162 since: 2018-09-26T11:03:57Z

*Publisher:*

Taylor & Francis Group

*Published*

DOI:10.1080/14606925.2017.1352690

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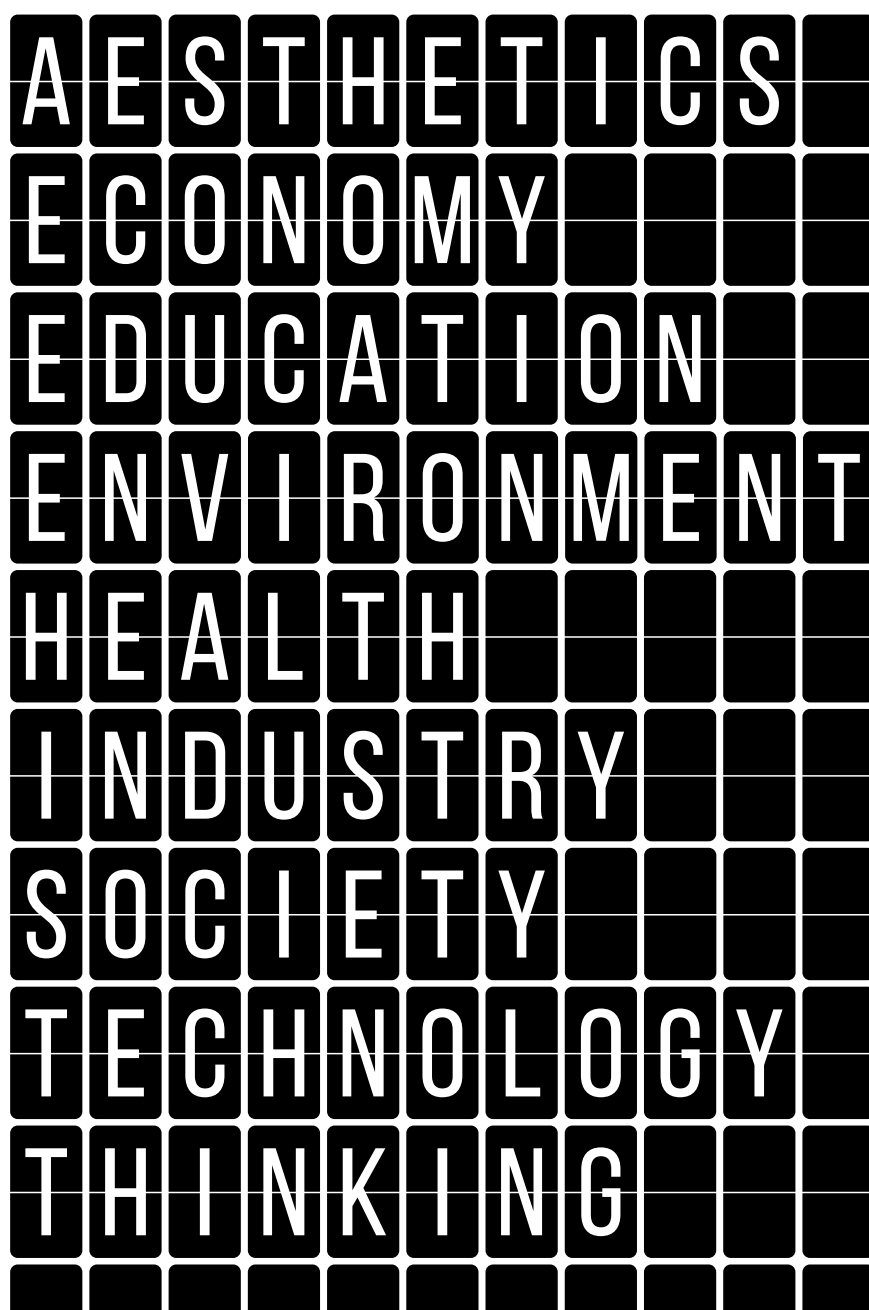
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# DESIGN FOR NEXT

designfornext.org

Proceedings of the 12th  
European Academy of Design Conference.  
Sapienza University of Rome, 12-14 April 2017  
*supplement of The Design Journal*

*edited by*  
Loredana Di Lucchio, Lorenzo Imbesi, Paul Atkinson



The European  
Academy  
of Design

SAPIENZA  
UNIVERSITÀ DI ROMA



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# Contents

## EDITORIAL

SV	<b>Conference track contents</b>
SXXV	<b>Foreword</b> <i>Paul Atkinson</i>
SXXVI	<b>Introduction: Designing a Design Conference</b> <i>Loredana Di Lucchio, Lorenzo Imbesi</i>
SXXVIII	<b>Keynote speakers</b>
SXXIX	<b>About</b>
SXXX	<b>People</b>
SXXXII	<b>Conference Tracks &amp; Track Chairs</b>
S1	<b>Design for Next Challenges</b> <i>Loredana Di Lucchio</i>
S9	<b>Design for Next Design</b> <i>Lorenzo Imbesi</i>

## CONFERENCE TRACK CONTRIBUTIONS

S16	<b>Design for Next Aesthetics</b>
S411	<b>Design for Next Economy</b>
S732	<b>Design for Next Education</b>
S1558	<b>Design for Next Environment</b>
S1978	<b>Design for Next Health</b>
S2592	<b>Design for Next Industry</b>
S2858	<b>Design for Next Society</b>
S3643	<b>Design for Next Technology</b>
S4171	<b>Design for Next Thinking</b>
S4671	<b>Workshops</b>
S4726	<b>Posters</b>

# Conference Track contributions

## DESIGN FOR NEXT AESTHETICS

- S16 **A Framework For Product Design Based On Semantic Attribution Process** *Itsaso Gonzalez, Este Val, Daniel Justel, Ion Iriarte*
- S28 **A Semiotic Rosetta Stone: Developing a Designer-centric Meta-language of Pragmatic Semiotics** *Dave Wood*
- S38 **Aesthetic Justice. Design for a blind-spot culture**  
*Peter Buwert*
- S49 **Aesthetics in Design Semiotics Research. Developing foundations to better comprehend cultural habits and codes in bottom-up design processes** *Felipe Domingues, Salvatore Zingale, Dijon De Moraes*
- S63 **Aesthetics of futures. Shaping shared visions of tomorrow**  
*Manuela Celi, Elena Formia*
- S77 **An Art-based research laboratory translated into a Critical Design strategy**  
*Raphaële Bidault-Waddington*
- S89 **Beautiful interfaces. From user experience to user interface design**  
*Letizia Bollini*
- S102 **Building networks for knowledge exchange, and design strategies for climate futures.**  
*Henry Mainsah, Andrew Morrison, Håkan Edeholt*
- S110 **Can Timelessness through Prototypicality Support Sustainability? A Strategy for Product Designers** *Rachel Flood Heaton, Deana McDonagh*
- S122 **Contested Surfaces. Aesthetics of Colonization for Urban Coexistence**  
*Adriana Cuéllar, Marcel Sanchez Prieto*
- S134 **Creative Interpretation in Web Design Experience**  
*Johanna Silvennoinen, Rebekah Rousi, Laura Mononen*
- S146 **Design fiction, culture and climate change. Weaving together personas, collaboration and fabulous futures** *Andrew Morrison, Alittea Chisin*
- S160 **Design for Next... Year. The Challenge of Designing for Material Change**  
*Ben Bridgens, Debra Lilley*
- S172 **Entropy: Unpacking the form through post digital making**  
*Evelina Kourteva, Dermott Mc Meel*
- S184 **Exploring aesthetics through digital jewellery**  
*Maarten Versteeg, Johanna Kint*
- S196 **Future Aesthetics of Technology; context specific theories from design and philosophy of technology** *Wouter Eggink, Jeroen Snippert*
- S209 **House and Yacht: the Aesthetics of the Interior as a Link between Different Sectors**  
*Mariateresa Campolongo*
- S219 **Living on the Edge: design artefacts as boundary objects**  
*Michael Pierre Johnson, Jen Ballie, Tine Thorup, Elizabeth Brooks*
- S236 **"Make it beautiful". An old request with difficult academic answers**  
*Silvia D. Ferraris, Lucia Rampino, Venere Ferraro*
- S249 **Metamorphosis of design. The aesthetics of the dark side** *Francesca La Rocca, Chiara Scarpitti*

- S261 **Metaphorical spaces. The art used by designers to explore, experiment and express concepts of Interiors** *Raffaella Trocchianesi, Matteo Pirola*
- S273 **Micronarratives as the form of contemporary communication**  
*Simona Venditti, Francesca Piredda, Walter Mattana*
- S283 **Network Time Where it Counts. Temporality and Critical Approaches to Infrastructure**  
*Tom Schofield, Gabriella Arrigoni*
- S294 **Reimagining cinema: searching for an aesthetic of interaction design through cinema**  
*Nicolas Marechal, Joel Karamath*
- S304 **Returning the aesthetics to the heart of the design process. On the conflict between social design and product beauty** *Mario de Liguori*
- S317 **Self-organized matter: design and primitive future of the eidetic categories**  
*Fabrizio Gay, Irene Cazzaro*
- S332 **Semiotics and design: Towards an aesthetics of the artificial**  
*Matthew Holt*
- S342 **Smart Solutions, “Smart Aesthetics”?**  
*Anna Cecilia Russo, Marinella Ferrara*
- S354 **The Aesthetics of The Artificial – Critical Design’s Lost Dominion**  
*John Knight*
- S365 **The design of surfaces, between empathy and new figuration**  
*Spartaco Paris*
- S375 **The New Aesthetic of DIY-Materials**  
*Camilo Ayala-Garcia, Valentina Rognoli*
- S390 **Who’s in charge? End-users challenge graphic designers’ intuition through visual verbal co-design** *Simone Taffe*
- S401 **Wrapping Cultural Values: using Social Embodiment as Stimulus in Designs**  
*Lizette Reitsma, Elise van den Hoven*

## DESIGN FOR NEXT ECONOMY

- S411 **Adding plus value to development aid projects through design strategy: experiences from Pakistan** *Gwendolyn Kulick*
- S424 **Beyond customer satisfaction. Supporting organisational change through Service Design. A case study in the insurance industry** *Ion Iriarte, Alazne Alberdi, Elisabeth Urrutia, Daniel Justel*
- S435 **Big Data: Understanding how Creative Organisations Create and Sustain their Networks**  
*Fraser Bruce, Jackie Malcolm, Shaleph O’Neill*
- S444 **Co-creating finances. A new perspective on designing for the financial world.**  
*Santiago de Francisco Vela*
- S457 **Design and Academic Entrepreneurship. The Role of Design in Spin-off Processes**  
*Anna Sinell, Franziska Brodack, Sebastian Denef*
- S469 **Design and design management in the incubation phase of high-tech start-ups**  
*Claudia Acklin, Andres Wanner*
- S479 **Design-driven innovation: Making meaning for whom?**  
*Heleen de Goey, Per Hilletoft, Lars Eriksson*
- S492 **Designing for the next (Circular) Economy. An appeal to renew the Curricula of Design Schools** *Michael Leube, Dominik Walcher*

- S502 **Discussing a New Direction for Design Management through a New Design Management Audit Framework** *Fulden Topaloğlu, Özlem Er*
- S522 **Hacking the organization: Organizational Transformation by Design**  
*Hans Kaspar Hugentobler*
- S531 **Involving stakeholders towards service implementation. Co-designing change of practices using a visual language** *Tim Overkamp, Freya Ruijs*
- S550 **Materiality Matters: Exploring the use of design tools in innovation workshops with the craft and creative sector in the Northern Isles of Scotland** *Cara Broadley, Katherine Champion, Lynn-Sayers McHattie*
- S566 **New Design Thinking Tools for the Next Generation of Designer-Entrepreneurs**  
*Sara Colombo, Cabirio Cautela, Lucia Rampino*
- S581 **Raising new opportunities for the Next Economy by exploring variable user needs for Computational Co-Design** *Viktor Malakuczi*
- S589 **Rethinking the Fashion Collection as a Design Strategic Tool in a Circular Economy**  
*Ulla Ræbilda, Anne Louise Bang*
- S600 **Service Design as a Cultural Intermediary. Translating cultural phenomena into services**  
*Claire Dennington*
- S614 **Service design as the ground for alternative social and economic scenarios**  
*Maria Antonietta Sbordone, Nicola Morelli*
- S622 **Setting-up a Design Factory within a Creative Science Park @Aveiro Region**  
*Teresa Franqueira, Cátia Pereira, Raul Pinto, Gonçalo Gomes*
- S635 **The choice of design. From businesses' conditions to businesses' attitudes**  
*Mariana Fonseca Braga*
- S647 **The Commodity of Trade in Contemporary Design**  
*Giovanni Innella, Paul Anthony Rodgers*
- S669 **THE FUTURE OF DESIGN SUPPORT: What Can We Learn From Design Support Experience in the UK, Estonia and Turkey?** *Melehat Nil Gulari, Ruth-Helene Melioranski, Ozlem Erc, Chris Fremantle*
- S681 **The Value of Agile Methods in Designing for Behavioural Change: A Case Study** *Dirk Ploos van Amstel, Martine Heemskerk, Reint Jan Renes, Sander Hermesen*
- S691 **The Value of Design in Innovation: results from a survey within the UK Industry** *Ricardo J Hernandez, Rachel Cooper, Bruce Tether, Emma Murphy*
- S705 **Universities' experience with brand. The role of design in managing university communication and branding.** *Veronica Dal Buono, Fulvio Fortezza*
- S721 **Why do I love you Vaatelainaamo? Analysis of motivations, barriers and opportunities in a Finnish service for sharing clothes** *Rosana Aparecida Vasques, Mikko Koria, Maria Cecilia Loschiavo dos Santos*

## DESIGN FOR NEXT EDUCATION

- S732 **A contemporary didactics of innovation in product design. Grip Factors identification and evaluation** *Marco Mancini*
- S745 **A conversation with material**  
*Nicolai de Gier*
- S754 **A Design Thinking approach to introduce entrepreneurship education in European school curricula** *Ester Val, Itsaso Gonzalez, Ion Iriarte, Amaia Beitia, Ganix Lasa, Maite Elkorro*

S767	<b>A design-relevant mindfulness device</b> <i>Fernando Rojas, Stuart English, Robert Young, Nicholas Spencer</i>
S781	<b>A dialogical model for studio critiques in Design Education</b> <i>Gaia Scagnetti</i>
S792	<b>A Future Scenario for a Methodological Approach applied to PhD Design Research. Development of an Analytical Canvas</b> <i>Violeta Clemente , Katja Tschimmel, Fátima Pombo</i>
S803	<b>A Multilevel Approach for Social Transformations and its Implications on Service Design Education.</b> <i>Nicola Morelli, Amalia De Götzen</i>
S814	<b>Advanced Design as a paradigm for design education: learning systems within its platforms and practices</b> <i>Roberto Iñiguez Flores, Ruth León Morán</i>
S822	<b>Algorithmic Futures. The Analog Beginnings of Advanced Parametric Design in First Year Studios</b> <i>Patrick Sean Rhodes</i>
S835	<b>An Interdisciplinary Design Education Framework</b> <i>Hye-Jin Nae</i>
S848	<b>Best Practices in Design Education Leads to a New Curriculum</b> <i>Ana Thudichum Vasconcelos</i>
S859	<b>Creative puzzlement: how deconstructing elements of object facilitates industrial design student's imagination</b> <i>Neil Smith, Shiro Inoue, Nick Spencer, Andy Tennant</i>
S875	<b>Culture as a design “next”: Theoretical frameworks to guide new design, development, and research of learning environments</b> <i>Tutaleni I. Asino, Lisa A. Giacumo, Victoria Chen</i>
S886	<b>Dealing with wicked problems, in messy contexts, through prototyping</b> <i>Bo Westerlund, Katarina Wetter-Edman</i>
S900	<b>Design as a process tool of collaborative and multidisciplinary learning in society</b> <i>João Bernarda, Ana M. Ferreira, Carlos Silva, Inês Queiroz</i>
S915	<b>Design Culture in school. Experiences of design workshops with children</b> <i>Fabrizio Pierandrei, Elena Marengoni</i>
S927	<b>Design for social change and design education: Social challenges versus teacher-centred pedagogies</b> <i>Nicos Souleles</i>
S937	<b>Design for Social Sustainability. An educational approach for insular communities</b> <i>Valentina Vezzani, Susana Gonzaga</i>
S952	<b>Design ResearchScape. A visual exploration of Design Research publications</b> <i>Stefano Perna</i>
S964	<b>Design Thinking for Textiles: let's make it meaningful</b> <i>Louise Valentine, Jen Ballie, Joanna Bletcher, Sara Robertson, Frances Stevenson</i>
S977	<b>Design Thinking: A New Road Map In Business Education</b> <i>Gözde Çeviker-Çınar, Gökhan Mura, Melike Demirbağ-Kaplan</i>
S988	<b>Designing a cultural event as an inclusive educational activity</b> <i>Davide Fassi, Agnese Rebaglio, Annalinda De Rosa</i>
S1000	<b>Designing Design Education. An articulated programme of collective open design activities</b> <i>Luisa Collina, Laura Galluzzo, Stefano Maffei, Vanessa Monna</i>
S1014	<b>Designing more responsible behaviours through Design Education: Reflections on a Brazilian pilot experience in Social Innovation for Sustainability</b> <i>Viviane G. A. Nunes</i>
S1026	<b>E-LEARNING AND DESIGN PRACTICE. Tools and methods for professional learning of strategic design approach</b> <i>Arianna Vignati, Luca Fois, Michele Melazzini, Xue Pei, Francesco Zurlo</i>

S1037	<b>Facebook as a Boundary Object in Industrial Design Studio. A SoTL Study</b> <i>Işıl Oygür, Selen Devrim Ülkebaş</i>
S1048	<b>Flourishing in graphic design education: incorporating Ubuntu as a curricular strategy.</b> <i>K.A. Chmela-Jones</i>
S1058	<b>From a master of crafts to a facilitator of innovation. How the increasing importance of creative collaboration requires new ways of teaching design.</b> <i>Andrea Augsten, Moritz Gekeler</i>
S1072	<b>Getting Creative Again. Getting Creative Again</b> <i>Josiena Gotzsch</i>
S1080	<b>Human and Technological Dimensions of Making in FabLab</b> <i>Iván Sánchez Milara, Georgi V. Georgiev, Jukka Riekk, Jani Ylioja, Mikko Pyykkönen</i>
S1093	<b>Ikebana: A Collaborative Design Pedagogy</b> <i>Rachel Kelly</i>
S1106	<b>Infusing management education with design to foster resilience, adaptability and flexibility</b> <i>Noemi Sadowska, Lorna Dallas-Conte</i>
S1118	<b>Interrogating Futures in Industrial Design Education</b> <i>Saliha Türkmenoğlu Berkan, Özlem Er, Wolfgang Jonas</i>
S1130	<b>Is Design a Plus? A dilemma of disciplines when implementing design into academic education</b> <i>Søren Bolvig Poulsen, Peter Vistisen, Sune Klok Gudiksen</i>
S1140	<b>Learning Architectural Design. Material and Immaterial Aspects.</b> <i>Gerlinde Verhaeghe</i>
S1154	<b>Making Sense: Harnessing Communication through Prototyping</b> <i>Giovanni Innella, Paul A. Rodgers</i>
S1167	<b>Material Tinkering. An inspirational approach for experiential learning and envisioning in product design education</b> <i>Stefano Parisi, Valentina Rognoli, Marieke Sonneveld</i>
S1185	<b>Materials &amp; Manufacturing Methods selection in product design: Experiences in undergraduate programs</b> <i>Aline Souza, Rita Almendra, Lia Krucken</i>
S1197	<b>On Context, Concepts and Research: An Approach in Basic Design</b> <i>Dilek Akbulut, Hatice Kesdi</i>
S1212	<b>On The Teachers Role in Interactive Prototyping</b> <i>Jussi Mikkonen</i>
S1224	<b>PBL 2.0. Interdisciplinary, multicultural transformative sustainable education for design students</b> <i>Elad Persov, Roshni Udyavar Yehuda, Ruti Kantor, Barak Pelman</i>
S1241	<b>Preparing design students for the market: an initial investigation on the required knowledge and skills for graphic designers in Brazil</b> <i>Paulo Roberto Nicoletti Dziobczenski, Anamaria Amaral Rezende Galeotti</i>
S1250	<b>Reconstructing the critique. Using inclusive formative feedback in face-to-face and online communities of practice to improve knowledge acquisition in design education</b> <i>Lucia Miceli, Lynette Zeeng</i>
S1260	<b>Reflexive Practices for the Future of Design Education: An Exercise in Ethno-Empathy</b> <i>Manu J. Brueggemann, Angelika Strohmayer, Matthew Marshall, Nataly Birbeck, Vanessa Thomas</i>
S1270	<b>Rethinking the Design Studio-Centered Architectural Education. A Case Study at Schools of Architecture in Turkey</b> <i>Burkay Pasin</i>
S1285	<b>Rethinking the education of retail design. What are the competences a retail designer needs in this fast evolving discipline?</b> <i>Katelijan Quartier, Stephanie Claes, Jan Vanrie</i>
S1293	<b>Semiotics in Design Education. Semiotics by Design</b> <i>Michela Deni, Salvatore Zingale</i>



S1304	<b>Service Design pedagogy and effective student engagement: Generative Tools and Methods</b> <i>Hena Ali, Silvia Grimaldi, Monica Biagioli</i>
S1323	<b>‘Sketching’ the new designers - going wide, going deep and doing it together</b> <i>Rita Assoreira Almendra, Gonalo Falco</i>
S1336	<b>Systemic Design, from the content to the structure of education: new educational model.</b> <i>Chiara Battistoni, Silvia Barbero</i>
S1355	<b>Systemic Food Design.it A website that narrates food supply chains from a systemic perspective</b> <i>Franco Fassio</i>
S1367	<b>The Anatomy of a Multi-Sensory Design Course: Happy Sound Object</b> <i>Yasemin Soylu, Berrak Karaca algamcioėlu, Pelin Efilti, Oki Kasajim</i>
S1380	<b>The design brief: inquiry into the starting point in a learning journey</b> <i>Noemi Sadowska, Dominic Laffy</i>
S1390	<b>The Digital Corbeled Wall. A Pedagogical Approach to Digital Infrastructure and Traditional Craft</b> <i>James Stevens, Ayodh Kamath, Komal Sharma</i>
S1405	<b>The end of the “briefing” and “the client” in graphic design.</b> <i>Gonalo Falco, Rita Almendra</i>
S1415	<b>The Reflection of Experiential Knowledge Into Professional Practice: Case of Industrial Design Education</b> <i>Enver Tatlisu, iėdem Kaya</i>
S1430	<b>The street as teaching space. A case study</b> <i>Paul Woodruffe, Mandy Patmore</i>
S1448	<b>Theoretical studies and practical tools for a systemic design educational paradigm. Applications of Systems Thinking principles to design education</b> <i>Laura Dominici</i>
S1459	<b>Towards a University Design School. Restoring the value of tacit knowledge through assessment</b> <i>Lynne Whelan, Carmel Maher, Colin Deevy</i>
S1471	<b>Using Design Methods to Improve Design Quality: Verbalizers vs Visualizers</b> <i>Younjoon Lee, Jaewoo Joo</i>
S1485	<b>Vulnerable children as change-agents within their communities: an educational methodology co-designed in Namibia</b> <i>Valentina Salvi</i>
S1503	<b>Wearable Words: A case study applying Jewellery theory and practice to the education of Fine Art, Textiles Innovation and Design, Graphic Communication and Illustration students</b> <i>Roberta Bernabei</i>
S1511	<b>What students say about their work and what it says about their work. Toward the development of rhetorical practice in the educational design studio</b> <i>Myra Thiessen, Veronika Kelly</i>
S1521	<b>What’s Next in Design Education? Transforming role of a designer and its implications in preparing youth for an ambiguous and volatile future</b> <i>Ramneek Kaur Majithia</i>
S1530	<b>Why a Logbook? A backpack journey as a metaphor for product design education</b> <i>Violeta Clemente , Katja Tschimmel , Rui Vieira</i>
S1543	<b>World design. Educational approach for a new experience of sharing.</b> <i>Maria Antonietta Sbordone, Rosanna Veneziano</i>

## DESIGN FOR NEXT ENVIRONMENT

- S1558 **A second life for Contemporary Ruins. Temporary Adaptive Reuse strategies of Interior Design to reinterpret vacant spaces** *Barbara Camocini, Oxana Nosova*
- S1566 **An Integral Design Framework —designing a global village**  
*Fenja Sepers*
- S1580 **Architecture for Regenerating Living Ecosystems: Designing a clay module for a vaulted dome structure** *Miruna Sladescu, Caitilin de Bérigny, Glen Hill*
- S1596 **Bioplastics made from upcycled food waste. Prospects for their use in the field of design**  
*Cecilia Cecchini*
- S1611 **Circular Material Library. An Innovative Tool to Design Circular Economy**  
*Maarit Virtanen, Kati Manskinen, Sauli Eerola*
- S1620 **Circular Product Design. A Multiple Loops Life Cycle Design Approach for the Circular Economy** *Ana Mestre, Tim Cooper*
- S1636 **Climate Change. Design Teaching for a New Reality**  
*Paul Micklethwaite, Robert Knifton*
- S1651 **Creating 21st Century Global Citizens. A design-led systems approach to transformative secondary education for sustainability** *Nikolas Winter-Simat, Natalie Wright, Jaz Hee-jeong Choi*
- S1662 **Creating a Tool for Measuring the Social Value of Design**  
*Jea Hoo Naa, Youngok Choi, Andrew Walters, Busayawan Lam, Stephen Green*
- S1673 **Data Visualization Collection. How graphical representation can inspect and communicate sustainability through Systemic Design** *Barbara Stabellini, Chiara L. Remondino, Paolo Tamborrini*
- S1682 **DEMOCRATIC CARDBOARD. Materials and design for a sustainable society**  
*Davide Turrini*
- S1692 **Design for Leftovers. From Food Waste to Social Responsibility**  
*Marco Bozzola, Dorian Dal Palù, Claudia De Giorgi*
- S1705 **Design for social sustainability. A reflection on the role of the physical realm in facilitating community co-design.** *Mirian Calvo, Annalinda De Rosa*
- S1725 **Design Process and Sustainability. Method and Tools**  
*Marco Marseglia*
- S1738 **Designing material interaction to promote water saving. An exploration of sensory language** *Sara Bergamaschi, Lucia Rampino*
- S1751 **Designing on the Spot: Learning from the Social Design Projects in Gökçeada/Imbros Island** *Alayça Erözçelik, Burak Taşdizen*
- S1765 **Energy Performance Development of Non-regulated Retrofit Mass Housing Estates in Northern Cyprus** *Bertug Ozarisoy, Hasim Altan*
- S1782 **Envisioning the future of public lighting with citizens for upcoming technologies**  
*Olli Heiskanen, Karthikeya Acharya*
- S1794 **From Science to Design: the Design4Materials virtuous cycle**  
*Rossana Carullo, Cecilia Cecchini, Marinella Ferrara, Carla Langella, Sabrina Lucibello*
- S1807 **GreenTeam. A new educative approach to sustainable design**  
*Andrea Di Salvo, Silvia Barbero, Andrea Gaiardo, Giada Rivella*
- S1817 **‘I Believe in That Version of the Future’. Cli-Fi and Design Fictions as Dialogical Frameworks for Expert Engagements** *Lizette Reitsma, Stina Wessman, Elin Önnvall*
- S1827 **Information design as a tool for promoting renewable energy**  
*Susanna Vanhamäki, Antti Heinonen, Kati Manskinen, Mirja Kälviäinen*

- S1836 **Make the environment the (Next) Economy**  
*Vanessa Monna*
- S1852 **Material Resignification in the Amazon. A way to construct sustainability scenarios**  
*Fernanda Sarmento, Monica Moura*
- S1869 **Pocket Park: Product Urban design**  
*Francesco Armato*
- S1879 **REPEAT – Textile Design for PV Modules! Design-driven Strategies for Photovoltaic Modules** *Tina Moor, Brigitt Egloff, Tina Tomovic, Stephen Wittkopf*
- S1894 **Resilient Design: Mitigating Trepidation About Environmental Disasters**  
*Tonya Sweet, Catherine Caudwell*
- S1904 **Rethinking Water: A CAAS (City As A Spaceship) design approach**  
*Susan Fairburn, Barbara Imhof, Susmita Mohanty*
- S1916 **Shifting Conversations for Sustainability Transitions Using Participatory Design Visioning**  
*A. İdil Gaziulusoy, Chris Ryan*
- S1927 **Space4Inspiration: Survival Lab. Designing Countermeasures for Natural Disasters**  
*Annalisa Dominoni, Benedetto Quaquaro, Susan Fairburn*
- S1938 **Sustainable Design Futures: An open design vision for the circular economy in fashion and textiles** *Paul Smith, Jen Baille, Lynn-Sayers McHattie*
- S1948 **Sustainable Design: Circular Economy in Fashion and Textiles**  
*Debbie Moorhouse, Danielle Moorhouse,*
- S1960 **The Speedcycle: a design-led framework for fast and slow circular fashion lifecycles**  
*Kate Goldsworthy*
- S1971 **VEG-HIVE. An easy to grow veg-kit for urban farmers**  
*Erminia D'Itria, Loredana Di Lucchio*

## DESIGN FOR NEXT HEALTH

- S1978 **A Healthcare Wearable for Chronic Pain Management. Design of a Smart Glove for Rheumatoid Arthritis** *Gozde Goncu-Berk, Nese Topcuoglu*
- S1989 **A Multidisciplinary inspection of Dental Photography: What Do Dentist Think and What Can Designer Do?** *Yener Altiparmakogullari, Muhsin Cifter, Abdusselam Selami Cifter*
- S1998 **A Review on Future Directions in Hospital Spatial Designs with a Focus on Patient Experience** *Abdusselam Selami Cifter, Muhsin Cifter*
- S2010 **Co-designing co-design. Shifting the culture of practice in healthcare**  
*Paul Chamberlain, Rebecca Partridge*
- S2022 **Design and Disability. Developing New Opportunities for the Design Curriculum**  
*Emma Gieben-Gamal, Sónia Matos*
- S2033 **Design and Usability of the Next Medical Devices for the Home Care**  
*Francesca Tosi, Alessandra Rinaldi*
- S2044 **Design Experiments. Identifying areas for intervention and designing medical technology for adolescents and young adults with type 1 diabetes** *Gillian M. McCarthy, Edgar R. Rodríguez Ramírez, Brian J. Robinson*
- S2057 **Design facilitators' journeys through the jungle of Co- in healthcare**  
*Remko van der Lugt, Tanja van der Laan*
- S2068 **DESIGN FOR DUCHENNE. Guidelines for dwellings' construction or renovation for Muscular Dystrophy-Affected Families** *Michele Marchi, Giuseppe Mincoelli*

- S2078 **Design for Dysphagia: a new hardware-and-software mobile system to monitor patients' swallowing** *Niccolò Casiddu, Claudia Porfirione*
- S2090 **Design for the ambient assisted living**  
*Giuseppe Losco, Andrea Lupacchini, Luca Bradini, Davide Paciotti*
- S2109 **Design of non-speech sounds for human interaction. A conjunction between industrial design and psychology** *Eduardo Tapia Olmos*
- S2120 **Design probes and toolkits for healthcare: Identifying information needs in African communities through service design** *Ralitsa D. Debrah, Retha de la Harpe, Mugendi K. M'Rithaa*
- S2135 **Design research for the development of a Medical Emergency Ambulance. Design as a symbolic qualifier in the design of complex systems/products** *Augusto de Sousa Coelho, Vasco Branco*
- S2158 **Designing Care. How Design can improve medical products for a therapeutic wellbeing**  
*Angela Giambattista*
- S2168 **Designing for Aesthetic Disruption: Altering Mental Models in Social Systems through Designerly Practices** *Josina Vink, Katarina Wetter-Edman, Manuela Aguirre*
- S2178 **Designing for an ageing society: products and services**  
*Silvia Pericu*
- S2190 **Designing Industrial Design in the Highly Regulated Medical Device Development Process. Defining our valuable contribution towards usability** *MaryBeth Privitera*
- S2207 **Designing Interactive Music Systems with and for People with Dementia**  
*Alexander Müller-Rakow, Rahel Flechtner*
- S2215 **Designing Schools for Students on the Spectrum** *Ulrike Altenmüller-Lewis*
- S2230 **Designing Therapeutic Support for the People with Alzheimer's disease. A designerly way of Investigation** *Beril Imamogullari, Alessandro Biamonti*
- S2238 **Designing with Dignity: Social determinants of health and design research**  
*Diana Nicholas, Kiera Townsend, Yvonne Michael*
- S2247 **Discovering Service Variations through Service Prototyping**  
*Vanessa Rodrigues, Stefan Holmlid*
- S2258 **Emerging Trends and the Way Forward in Design in Healthcare: An Expert's Perspective**  
*Emmanuel Tsekles, Rachel Cooper*
- S2273 **Enhancing co-responsibility for patient engagement**  
*Ineke Neutelings, Pierre Levy, Tom Djajadiningrat, Caroline Hummels*
- S2284 **Environment as non pharmacological intervention in the care of Alzheimer's disease** *Silvia Maria Gramegna, Alessandro Biamonti*
- S2293 **Health Co-Creation in Social Innovation: Design Service for Health-Empowered Society in China** *Liang Yin, Davide Fassi, Hang Cheng, Han Han, Shushu He*
- S2304 **Health Design: Mapping current situations, envisioning next steps**  
*Guillermina Noël*
- S2315 **How can constraint-induced movement therapy for stroke patients be incorporated into the design of a tangible interface?The case study of the 'Biggest Hit'**  
*Mailin Lemke, Edgar Rodríguez Ramírez, Brian Robinson*
- S2336 **Imagined futures: designing future environments for the care of older people**  
*Claire Craig*
- S2348 **Improving the Pelvic Exam Experience: A Human-Centered Design Study**  
*Gina A Taylor, Deana McDonagh, Michael J Hansen*

- S2363 **Improving the Visualisation of Renal Blood Test Results to Enhance Patient – Clinician Communication** *Adrian Gradinar, Jeremy Davenport, Heather Hill, Paul Coulton*
- S2375 **Incremental and Radical Innovation: Design in Robotics for Autism. Teo and Riby robots. Evolutionary Development** *Maximiliano Romero, Andrea Bonarini, Andrea Brivio, Ksenia Rogacheva*
- S2389 **Informing hospital design through research on patient experience**  
*Margo Annemans, Liesbeth Stam, Jorgos Coenen, Ann Heylighen*
- S2397 **Limited use only. How can the design of an everyday object help chronic stroke patients to overcome the learned nonuse of the upper limb?** *Mailin Lemke, Edgar Rodríguez Ramírez, Brian Robinson*
- S2418 **Multisensory design of pocket gardens for reducing stress and improving well-being, performance and satisfaction** *Noemi Bitterman, Ella Simonov*
- S2426 **Participant Observation in Cognitive Gameplay as a Rehabilitation Tool for Living Alone Elderly with Dementia in Hong Kong: A Pilot Study** *Alex Pui-yuk King, Kin Wai Michael Siu*
- S2439 **Persuasive Technology as key to increase Working Health Condition. The Case study of a Wearable System to prevent Respiratory Disease** *Venere Ferraro, Mila Stepanovic, Silvia Ferraris*
- S2451 **SAM - Simulation Airways Models**  
*Elisabetta Cianfanelli, Lorenzo Corbetta, Gabriele Goretti, Lorenzo Pelosini, Maria Luisa Malpelo*
- S2463 **Sense and movement. Design of a system for sensorimotor rehabilitation after stroke.**  
*Francesca Toso*
- S2473 **Systemic Design for Sustainable Healthcare**  
*Silvia Barbero, Agnese Pallaro*
- S2486 **Systemic innovation in sustainable design of medical devices**  
*Silvia Barbero, Amina Pereno, Paolo Tamborrini*
- S2498 **The Effectiveness of Environmental Design for Physical Activities Promotion: Review**  
*Aline Gonzalez-Moreno, Aldo Valencia-Hernandez, Omar Valencia-Hernandez*
- S2524 **The fuzzy front-end and the forgotten back-end: User involvement in later development phases** *Frida Almqvist*
- S2534 **User-Designed Dementia Care Pathways. A disruptive approach to mapping dementia support services** *Daniel Carey, Andy Tennant, Paul Rodgers, Katie Dodd*
- S2551 **Wayfinding for health seeking: Exploring how hospital wayfinding can employ communication design to improve the outpatient experience**  
*Eden Jayne Short, Stephen Reay, Peter Gilderdale*
- S2569 **Well Connected. What does design offer in the complexity of blood donation management** *Tine Thorup, Jen Ballie, Marjan Angoshtari*
- S2580 **Will smart homes improve our lives? A design perspective towards effective wellbeing at home** *Margherita Pillan, Sara Colombo*

## DESIGN FOR NEXT INDUSTRY

- S2592 **A Design perspective for IoT products. A case study of the Design of a Smart Product and a Smart Company following a crowdfunding campaign.**  
*Ilaria Vitali, Venzio Arquilla, Umberto Tolino*
- S2605 **Changing roles. Role theoretical approach to customer involvement in industrial service development** *Sanna Peltonen*

S2616	<b>Design Absorption and Learning Processes: a study on designers' perceptions about companies.</b> <i>Ivna Ravanello, Fabiane Wolff, Andréa Capra</i>
S2625	<b>Design and the Fourth Industrial Revolution. Dangers and opportunities for a mutating discipline.</b> <i>Tomás García Ferrari</i>
S2634	<b>Design for Next Connected Appliances</b> <i>Eleonora Fiore, Paolo Tamborrini, Silvia Barbero</i>
S2645	<b>Designing Fast &amp; Slow. Exploring fashion textile product lifecycle speeds with industry designers</b> <i>Rebecca Earley</i>
S2657	<b>Digital Maker Networks. Benefits, barriers and opportunities for re-localised UK manufacturing for the future</b> <i>Paul Smith</i>
S2667	<b>Emotional service experience toolkit for servitization</b> <i>Miia Lammi</i>
S2679	<b>Fashion Design for Short Male Consumers</b> <i>Osmud Rahman, Henry Navarro</i>
S2689	<b>Footwear design. The paradox of "tailored shoe" in the contemporary digital manufacturing systems</b> <i>Annalisa Di Roma</i>
S2700	<b>Go with the Flow: Accelerated digital design in the age of Post-agility</b> <i>John Knight</i>
S2716	<b>Hospital of Objects. Recycling plastic from the small electronic devices to redesign old objects by the 3d printers</b> <i>Chiara Petruzzi, Loredana Di Lucchio, Lorenzo Maria Cafiero, Riccardo Tuffi, Alessio Ubertini, Flavio Caretto</i>
S2724	<b>Industry 4.0, Innovation and Design. A new approach for ergonomic analysis in manufacturing system</b> <i>Elena Laudante</i>
S2735	<b>Industry 4.0: Is It Time for Interaction Design Craftsmanship?</b> <i>Daniela Petrelli</i>
S2746	<b>Networked production and outsourced design. A comparison of three case studies</b> <i>Silvia Gasparotto</i>
S2760	<b>New vision on Knitwear design. How the traditional craft methodologies are evolving into fashion international scenarios.</b> <i>Laura Affinito, Giovanni Maria Conti, Martina Motta</i>
S2771	<b>Next generation of tools for industry to evaluate the user emotional perception: the biometric-based multimethod tools</b> <i>Ganix Lasa, Daniel Justel, Itsaso Gonzalez, Ion Iriarte, Ester Val</i>
S2778	<b>Scenarios for design and craft</b> <i>Manuel Martínez Torán, Chele Esteve Sendra, Ricardo Moreno Cuesta</i>
S2789	<b>Strategic innovation tools enabling nautical stakeholders to shape a next level port</b> <i>Garnt Nieuwsma, Ingrid Mulder</i>
S2803	<b>The Relation of Influence between Leadership Style and Team Creativity of Integrated Design Companie</b> <i>Yueh Hsiu Giffen Cheng, Teng-Jung Wang</i>
S2813	<b>The Role of Design Concepts in the Development of Digitalized Industrial Services</b> <i>Janne Pekkala, Salu Ylirisku</i>
S2823	<b>The understanding and use of design in the UK industry: reflecting on the future of design and designing in industry and beyond</b> <i>Ricardo J Hernandez, Rachel Cooper, Jeyon Jung</i>
S2837	<b>What does Product Design Mean Tomorrow? Example Middle East</b> <i>Andreas Sicklinger</i>
S2846	<b>Why the Internet of Things needs Object Orientated Ontology</b> <i>Joseph Lindley, Paul Coulton, Rachel Cooper</i>

## DESIGN FOR NEXT SOCIETY

- S2858 **Anamorphosis and Contemporaneity**  
*Tommaso Empler*
- S2873 **Built territories. Innovative regeneration processes for a participatory and sustainable design** *Marco Borsotti, Sonia Pistidda, Giulietta Fassino*
- S2883 **Call of Survival: Stigmergy for Matters of Concern**  
*Shanu Sharma, Koumudi Patil*
- S2894 **Con[temporary]. Design for social innovation**  
*Chiara Olivastri*
- S2906 **Containers of Stories: using co-design and digital augmentation to empower the museum community and create novel experiences of heritage at a house museum**  
*Caroline Claisse, Luigina Cioffi, Daniela Petrelli*
- S2919 **Craft and Sustainability: Potential for Design Intervention in Crafts in the Yangtze River Delta, China** *Xiaofang Zhan, Stuart Walker, Ricardo Hernandez-Pardo, Martyn Evans*
- S2935 **Crafting Sustainable Futures. The Value of the Service Designer in Activating Meaningful Social Innovation from within Textile Artisan Communities**  
*Francesco Mazzarella, Val Mitchell, Carolina Escobar-Tello*
- S2951 **Decentralising Design. Raising the Question of Agency in Emerging Design Practice**  
*Paola Pierri*
- S2960 **Design and Innovation in Brazil. Reflections on a local experience within the furniture industry sector** *Viviane G. A. Nunes*
- S2973 **Design by means of citizen activism: three cases illustrated by the action of Coletivo Maré, Rio de Janeiro, Brazil** *Bruna Montuori, Marcos Rosa, Maria Cecilia Santos*
- S2991 **Design for Grassroots Production in Eastern Turkey through the Revival of Traditional Handicrafts** *Hazal Gumus Ciftci, Stuart Walker*
- S3005 **Design for social enterprises. Co-designing an organizational and cultural change**  
*Daniela Selloni, Marta Corubolo*
- S3020 **Design for Society: Analysis of the adoption of Design practices by Early-Stage Social Entrepreneurs** *David Pérez, David Hands, Edward McKeever*
- S3035 **Design for Socio-technical Innovation: A Proposed Model to Design the Change**  
*Pablo Marcel de Arruda Torres*
- S3047 **Design for Territories as Practice and Theoretical Field of Study**  
*Marina Parente, Carla Sedin*
- S3059 **Design Paradox. The next chapter in the design process**  
*Daria Ayvazova*
- S3068 **Designing for the next generation. Children urban design as a strategic method to improve the future in the cities** *Laura Giraldi, Elisabetta Benelli, Roberta Vita, Isabella Patti, Jurji Filieri, Francesca Filippi*
- S3079 **Designing local food systems in everyday life through service design strategies**  
*Emily Ballantyne-Brodie, Ida Telalbasic*
- S3096 **Designing Trust: the importance of relationships in social contexts**  
*Dr Laura Warwick*
- S3106 **Digital commons, urban struggles and the role of Design**  
*Andreas Unteidig, Blanca Domínguez Cobreros, Elizabeth Calderon-Lüning, Gesche Joost*

S3121	<b>Engaged by Design: The Role of Emerging Collaborative Infrastructures for Social Development. Roma Makers as A Case Study</b> <i>Alessandra Fasoli, Silvio Tassinari</i>
S3134	<b>Enhancing textile enterprises for a more sustainable society, through design research and website development</b> <i>Disaya Chudasri, Krittiya Saksrisathapor</i>
S3152	<b>Fab Labs. New hubs for socialization and innovation</b> <i>Annalisa Di Roma, Vincenzo Minenna, Alessandra Scarcelli</i>
S3162	<b>Fair by design. Addressing the paradox of inclusive design approaches</b> <i>Matteo Bianchin, Ann Heylighen</i>
S3171	<b>Framing Design to support Social Innovation: The Open4Citizens Project</b> <i>Nicola Morelli, Marc Aguilar, Grazia Concilio, Amalia De Götzen, Ingrid Mulder, Janice Pedersen, Louise Klitgaard Torntoft</i>
S3185	<b>Freedome smart mobile office-home. The bio-logic design adaptation to the dynamic evolution of living</b> <i>Serena Fiorelli</i>
S3202	<b>From Cork Labour Activities to Co-design Production. Azaruja Case Study</b> <i>António Gorgel Pinto, Paula Reaes Pinto</i>
S3213	<b>Future Tense: Alternative Futures as a Design Method for Sustainability Transitions</b> <i>Corina Angheloiu, Goldie Chaudhuri, Leila Sheldrick</i>
S3226	<b>Harmonics: Towards Enlightened Evaluation</b> <i>Katherine Champion, George Jaramillo</i>
S3238	<b>Having a voice, having a choice: Children's Participation in Educational Space Design</b> <i>Eda Can, Göksenin İnalhan</i>
S3252	<b>Human movement in Public spaces: The use and development of motion-oriented design strategies</b> <i>Liselotte Vroman, Thierry Lagrange</i>
S3262	<b>Information Design for Supporting Collaborative Communities</b> <i>María de los Angeles Briones</i>
S3279	<b>Infrastructuring Place. Citizen-led Placemaking and the Commons</b> <i>Maria Frangos, Thomas Garvey, Irena Knezevic</i>
S3294	<b>Libraries of Things as a new form of sharing. Pushing the Sharing Economy</b> <i>Najine Ameli</i>
S3305	<b>Living mobility transitions towards bicycling. Designing practices through co-creation and socially influencing systems</b> <i>Tobias Barnes Hofmeister, Agnis Stibe</i>
S3317	<b>Makers' ambitions to do socially valuable things</b> <i>Elisabeth Unterfrauner, Christian Voigt</i>
S3326	<b>Making Visible: Valuating the Impacts of Design Intervention for Social Cooperative</b> <i>Xue Pei, Francesco Zurlo, Arianna Vignati, Luca Fois, Michele Melazzini</i>
S3340	<b>Masters of Cerimonies. A design approach to participatory video</b> <i>Francesca Piredda, Elisa Bertolotti, Simona Venditti</i>
S3354	<b>No Man is an Island. Situated Design Research and Wicked Impact</b> <i>Jeroen Peeters, Nigel Papworth, Pernilla Glaser, Carla Collevocchio, Ana Betancour, Ambra Trotto</i>
S3368	<b>Participatory Design for Public Services. Innovation in Public Administration</b> <i>Gianni Sinni</i>
S3380	<b>People's Republic of Bolzano or how digital artifacts can be adversarial to misinformation</b> <i>Matteo Moretti, Maurizio Teli, Antonella De Angeli</i>
S3393	<b>Places, Communities and Knowledge. You'll be part of an upcoming exhibition</b> <i>Alfredo Calosci</i>
S3401	<b>Providing Fast Flowing Calm Waters. The role of the Design Manager in mid-large scale Public Sector Co-Design Projects</b> <i>Gemma Coupe, Leon Cruickshank</i>



- S3413 **REAGENTE. A label for social innovation.**  
*Raffaella Fagnoni, Silvia Pericu, Chiara Olivastri*
- S3425 **Research on Service Blueprint of Food Banks**  
*Pin Hsuan Kuang, Wen Hui Chou*
- S3436 **Sacred design. Immaterial values, material culture**  
*Luisa Chimenz*
- S3448 **Sharing Economy for Tourism and Hospitality: new ways of living and new trends in interior design** *Luisa Collina, Laura Galluzzo, Giulia Gerosa, Maddalena Bellè, Maria Lidia Maiorino*
- S3464 **Social Design for Service. Building a Framework for Designers Working in the Development Context** *Essi Kuure, Satu Miettinen*
- S3475 **Socially Engaged Transmedia Practice. Three Co-Creative Interventions in Portuguese Neighbourhoods** *António Gorgel Pinto*
- S3486 **Storytelling in design for social innovation and politics: a reading through the lenses of Hannah Arendt** *Virginia Tassinari, Francesca Piredda, Elisa Bertolotti*
- S3496 **Systemic Design approach in policy-making for sustainable territorial development**  
*Silvia Barbero, Miriam Bicocca*
- S3507 **Tackling local problems by embedding design in local administrative offices: A case study of the 'Design Consultant' program** *Eun Ji Cho*
- S3516 **THE CHALLENGE OF BEING ACTIVIST-DESIGNER. An attempt to understand the New Role of Designer in the Social change based on current experiences** *Maziar Rezai, Mitra Khazaei*
- S3536 **The emerging challenge of brand design and brand management in social innovations**  
*Tamami Komatsu Cipriani*
- S3546 **The growth of digital social innovation in Europe. An Open Design approach to support innovation for the societal good** *Serena Cangiano, Zoe Romano, Matteo Loglio*
- S3560 **The Museum of the Future: a sedimentary cloud**  
*Craig Bremner, Laura Bernadet*
- S3569 **The role of design in supporting the continual emergence of hybrid spaces of interaction within the city** *Valentina Volpi, Antonio Opromolla*
- S3578 **The Social Purpose of Design Activity**  
*Xuesong Wu*
- S3589 **Towards a new "urban sensitivity". The role of design as support to social innovation**  
*Barbara Di Prete, Martina Mazzarello*
- S3601 **Unearth Hidden Assets through Community Co-design and Co-production**  
*Busayawan Lam, Theodore Zamenopoulos, Mihaela Kelemen, Jea Hoo Na*
- S3611 **UTOPIA\_an Italian way to practice transdisciplinarity. Educating alterity**  
*Valentina Frosini*
- S3620 **Working with young people at the margins of society to design hybrid physical/digital objects to portray their experiences of support services** *Daniel Burnett, Paul Coulton*
- S3630 **You say you want a revolution? Non-normative foundations of Transformation Design**  
*Peter Friedrich Stephan*

## DESIGN FOR NEXT TECHNOLOGY

- S3643 **A data-driven approach for understanding Open Design. Mapping social interactions in collaborative processes on GitHub** *Massimo Menichinelli*
- S3659 **A Framework for Capturing Creativity in Digital Fabrication**  
*Georgi V. Georgiev, Iván Sánchez Milara, Denzil Ferreira*
- S3669 **A Heuristic for Improving Transmedia Exhibition Experience**  
*Vashanth Selvadurai, Claus Andreas Foss Rosenstand*
- S3683 **A study of the relationship between personalised 3D printed ‘Souvenirs of Place’ and public perception of modern architectural heritage.** *Samantha Forster, Katherina Vones, Constantia Anastasiadou*
- S3696 **Adopting the Unknown through the Known Supporting user interaction of non-idiomatic technologies in exhibitions through known idioms of conventional technologies**  
*Peter Vistisen, Claus Pertou Østergaard, Rameshnath Kala Krishnasamy*
- S3707 **:Blackbox: A Design Fiction research project**  
*Alfonso Tiberio, Lorenzo Imbesi*
- S3713 **Collaboration and exchange between “Craftsman” and “Designer”: Symbiosis towards Product Innovation.** *Handan Temeltaş*
- S3724 **Conceptualising Kinaesthesia – Making Movement Palpable**  
*Lise Amy Hansen, Wendy Keay-Bright, Damian Milton*
- S3735 **Crafting the Digital: Developing expression and materiality within digital design and manufacture** *David Grimshaw*
- S3749 **Design and Planned Obsolescence. Theories and Approaches for Designing Enabling Technologies.** *Matteo Zallio, Damon Berry*
- S3762 **Design problem analysis and process. A case of technology-augmented problem decomposition in analysis and understanding of public space** *Awoniyi Stephen*
- S3776 **Design Thinking Applied to Data Storage Innovation: A Case Study**  
*Maliheh Ghajargar, Giulio Mangano, Alberto De Marco, Roberta Giannantonio*
- S3789 **Designing The “Next” Smart Objects Together With Children**  
*Seçil Uğur Yavuz, Nitzan Cohen, Roberta Bonetti*
- S3801 **Designing the Next Generation of Connected Devices in the Era of Artificial Intelligence**  
*Alexander Schurig, Colin George Thomas*
- S3811 **DIY: polar fleece as a new material for handmade artefacts.**  
*Beatrice Lerma*
- S3824 **Effect of Digital Age on the Transmission of Cultural Values in Product Design**  
*Betül Aybala Çakmakçioğlu*
- S3837 **Empathy Workshop: When Project team and Pilot Users Exchange Experiences**  
*Maliheh Ghajargar, Lucia Longo, Eleonora Gargiulo, Roberta Giannantonio*
- S3849 **Fiction and Physicality: a designerly approach towards complexities of emerging technologies** *Yeup Hur, Miriam Sturdee, Migeul Bruns Alonso, Panos Markopoulos, Jason Alexander*
- S3863 **Flying with data: Openness, forms and understanding.**  
*Nick Dulake, Ian Gwilt*
- S3873 **From Design for One to Open-ended Design. Experiments on understanding how to open-up contextual design solutions** *Francesca Ostuzzi, Lieven De Couvreur, Jan Detand, Jelle Saldien*
- S3884 **From respect to change user behaviour. Research on how to design a next generation of smart home objects from User Experience and Interaction Design** *Yichen Wu, Margherita Pillan*

S3899	<b>Humans, Machines and the Design Process. Exploring the Role of Computation in the Early Phases of Creation</b> <i>Philippa Mothersill, V. Michael Bove Jr.</i>
S3914	<b>Interaction design applications for museum spaces. New exhibit paths driven by a Bluetooth sensor's system</b> <i>Claudio Germak, Sara Khan</i>
S3925	<b>Interaction design for cultural heritage. A robotic cultural game for visiting the museum's inaccessible areas.</b> <i>Germak Claudio, Giuliano Luca, Lupetti Maria Luce</i>
S3935	<b>Interface and Data Biopolitics in the Age of Hyperconnectivity. Implications for Design</b> <i>Salvatore Iaconesi</i>
S3945	<b>Jamming as a design approach. Power of jamming for creative iteration</b> <i>A. Tece Bayrak</i>
S3954	<b>Lifelogging in User Experience Research: Supporting Recall and Improving Data Richness</b> <i>Mattias Arvola, Johan Blomkvist, Fredrik Wahlman</i>
S3966	<b>Making and Unfinishedness: Designing Toolkits for Negotiation</b> <i>Michael Smyth, Ingi Helgason</i>
S3975	<b>Museum Experience Design: A Modern Storytelling Methodology</b> <i>Federica Dal Falco, Stavros Vassos</i>
S3984	<b>My Boy Builds Coffins</b> <i>Gianni Denaro, Lorenzo Imbesi</i>
S3996	<b>Research through provocation: a structured prototyping tool using interaction attributes of time, space and information.</b> <i>Jaime Rivera, Tom MacTavish</i>
S4009	<b>Rethinking the Role of Design within the Technological Advancements in Biomimetics and SynBio</b> <i>Toufic Haidamous</i>
S4019	<b>Silk Road: A Reference. Creating public architectural intervention in the context of education &amp; technology.</b> <i>Marcus M. Farr</i>
S4038	<b>Speculating the Possibilities for Remote Collaborative Design Research. The Experimentations of a Drawing Robot</b> <i>Catherine Normoyle, Rebecca Tegtmeyer</i>
S4052	<b>Technological Research and Invention In The Industrial Design</b> <i>Mario Buono, Sonia Capece</i>
S4065	<b>Textile Connections E-textiles to enhance connectedness for older adults experiencing loneliness</b> <i>Sara Nevay, Christopher S.C. Lim, Gary Gowans</i>
S4076	<b>The cocktail party effect. An inclusive vision of conversational interactions</b> <i>Isabella Loddo, Dario Martini</i>
S4087	<b>The future of print design relies on interaction</b> <i>Marco Neves</i>
S4101	<b>The Map As An Object of Service Design</b> <i>Qian Sun, Hyunyim Park</i>
S4120	<b>'The Robots are Coming!': Perennial problems with technological progress</b> <i>Paul Atkinson</i>
S4132	<b>TXD. From Traceability to Experience Design in Fashion Accessories Production.</b> <i>Elisabetta Cianfanelli, Gabriele Goretti</i>
S4146	<b>Using Design Fiction to Inform Shape-Changing Interface Design and Use</b> <i>Miriam Sturdee, Paul Coulton, Jason Alexander</i>
S4158	<b>When Your Toaster is a Client, how do you design? Going Beyond Human Centred Design</b> <i>Leon Cruickshank, Nina Trivedi</i>

## DESIGN FOR NEXT THINKING

- S4171 **A case of values conflict in the video game design field. A critique of Schön's appreciative system.** *Laureline Chiapello*
- S4183 **Adaptive Thinking for Design Leadership. Coaching adaptive capabilities to empower next visionary leaders** *Francesco Galli, Barbara Pino A., Irina Suteu*
- S4197 **Analysing the Digital Transformations, Territories, Frames and Uses**  
*Mario Gagliardi*
- S4213 **Cause and Effect of Design Features and Brand Value: Consumer Interpretation of Design and Value of Long- and Short-Term Products** *Kana Sugimoto, Shin'ya Nagasawa*
- S4227 **Channelizing Thinking for Practical Innovations and Measurable Impact**  
*Kalyani Khodke, Sagar Behere*
- S4241 **CO/DEsign: building a shared dialogue around analysis within co-design**  
*Michael Pierre Johnson, Jen Ballie, Tine Thorup, Elizabeth Brooks, Emma Brooks*
- S4253 **Critical design as approach to next thinking**  
*Liene Jakobsone*
- S4263 **Design Education at the Boundary**  
*Robert Potts*
- S4281 **Design for Next Thinking. Using Transformation Consequence Mapping to Improve Responsible Innovation Practices** *Ashleigh Bentham*
- S4292 **Design for Subjective Wellbeing: Towards a Design Framework for Constructing Narrative**  
*Patrick W. Jordan, Andy Bardill, Kate Herd, Silvia Grimaldi*
- S4307 **Design in the Middle: A New Approach to Collaborative Socio-political Design in Conflict Areas** *Merav Perez, Ezri Tarazi*
- S4319 **Designing for Violence. And its undoing**  
*Stahl Stenslie*
- S4331 **Design-led Approach to Co-production of Values for Collective Decision-Making**  
*Sneha Raman, Tara French, Angela Tulloch*
- S4343 **Driverless Governance. Designing Narratives Toward Democratic Technology**  
*Melika Alipour Leili, Winnie Tsai Chang, Corey Chao*
- S4357 **Empathy and Design. A new perspective**  
*Alice Devecchi, Luca Guerrini*
- S4365 **Envisioning urban futures: from narratives to composites.**  
*Serena Pollastri, Christopher Boyko, Rachel Cooper, Nick Dunn, Stephen Clune, Claire Coulton*
- S4378 **Foucault and the smart city**  
*Ding Wang*
- S4387 **Grounding Evidence in Design: Framing Next Practices**  
*Altuğ Kasalı, Nancy J. Nersessian*
- S4398 **Idea Management. Identifying the factors that contribute to uncertainty in idea generation practices within front end NPD** *Se Ryeong Kim*
- S4409 **Implementation during design Developing understanding about service realisation before implementation** *Tim Overkamp, Stefan Holmlid*
- S4422 **Meaning, knowledge and artifacts, giving a voice to tacit knowledge**  
*Spyros Bofylatos, Thomas Spyrou*
- S4434 **Outside the "Comfort Zone". Designing the Unknown in a Multidisciplinary Setting**  
*Kirsi Niinimäki, Marjaana Tanttu, Cindy Kohtala*

S4444	<b>Paradoxes in Design Thinking</b> <i>Paul A. Rodgers, Giovanni Innella, Craig Bremner</i>
S4459	<b>Potentiality: the ethical foundation of design</b> <i>Peter Buwert</i>
S4468	<b>Prototyping the non-existent as a way to research and innovate: a proposal for a possible framework for design research and innovation</b> <i>Juan De la Rosa</i>
S4477	<b>Rethinking the Roles of Fashion Designers. The Case of Pre Helsinki</b> <i>Namkyu Chun, Olga Gurova, Kirsi Niinimäki</i>
S4487	<b>Scalable Interactive Modular Systems (SIMS): sustainability for digital interfaces</b> <i>Luigi Ferrara, Nastaran Dadashi, Robert Giusti</i>
S4497	<b>Scientific Craftsmanship: The changing role of product designers in the digital era</b> <i>Muhammet Ramoğlu, Aykut Coşkun</i>
S4509	<b>Stimulating Thinking at the Design Pitch. Storytelling Approach and Impact</b> <i>David Parkinson, Laura Warwick</i>
S4519	<b>Synesthetic Approach in the Design Process for Enhanced Creativity and Multisensory Experiences</b> <i>Sevi Merter</i>
S4529	<b>Systems thinking and its contribution to understanding future designer thinking</b> <i>Laura Mononen</i>
S4539	<b>Terms and meanings of “participation” in product design: From “user involvement” to “co-design”</b> <i>Lucía Sánchez de la Guía, Marina Puyuelo Cazorla, Blanca de-Miguel-Molina</i>
S4552	<b>The Constellation: A framework for conceptualising design as a process of innovation.</b> <i>Joanna Bletcher</i>
S4565	<b>The design movement: Two case studies from the edge of the discipline</b> <i>Rebecca Price, Karla Straker</i>
S4575	<b>The use of intuition during scenario building activities in design projects</b> <i>Priscilla Ferronato, Stan Ruecker, Celso Scaletsky</i>
S4584	<b>To the new methodology of design consciousness for the futures</b> <i>Galina Lola, Tatiana Aleksandrova</i>
S4591	<b>Towards prospective design</b> <i>Bridgette Engeler</i>
S4600	<b>Ubiquitous Design. Ethnographic glances toward syncretisms, polyphonies, meta-fetishisms</b> <i>Massimo Canevacci</i>
S4611	<b>Understanding Collaborative Design Through Activity Theory</b> <i>Mithra Zahedi, Virginie Tessier, Dave Hawey</i>
S4621	<b>User, Research, and Practice. Learning from Design Consultancies</b> <i>Işıl Oygür</i>
S4632	<b>Vapourworlds and Design Fiction: The Role of Intentionality</b> <i>Paul Coulton, Joseph Lindley</i>
S4643	<b>What counts when counting gets complicated?</b> <i>Elizabeth Wright, Simon Fraser, Thomas Eugene Wright Jr.</i>
S4652	<b>Yellow as “Non-Black”: Prosthetics, Semiotics, Hermeneutics, Freedom and Function</b> <i>Jonathan Ventura, Galit Shvo</i>

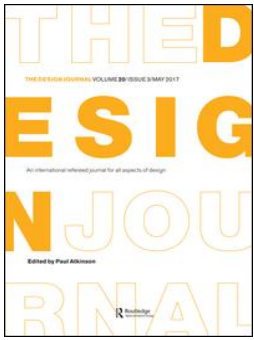
## WORKSHOPS

- S4671 **Discussing about “Inclusion in Sharing-Based Services”. A design workshop using an analytic tool** *Daniele Busciantella Ricci, Hua Dong, Alessandra Rinaldi, Francesca Tosi*
- S4678 **Eco-social design: who pays for it?**  
*Bianca Elzenbaumer, Fabio Franz, Kris Krois, Alvise Mattozzi*
- S4683 **Experiencing Technology Enabled Empathy Mapping**  
*Daniel Neubauer, Verena Paepcke-Hjeltness, Pete Evans, Betsy Barnhart, Tor Finseth*
- S4690 **Model and Mobilise Imaginary for Innovative Experience Design**  
*Estelle Berger, Frédérique Pain*
- S4697 **Pablo Escobar: Zoomania in the narco imperium. The glorification of the cocaine network**  
*Catalina M Jaramillo*
- S4710 **Perspectives on socially and politically oriented practices in design**  
*Bianca Herlo, Andreas Unteidig, Wolfgang Jonas, İdil Gaziulusoy*
- S4714 **Spirit of ‘68. The ‘next’ role of the art/design school?**  
*Jo Turney, Alex Franklin*
- S4721 **Strategies for synergies. Working in interdisciplinary teams**  
*Hannah Glatte, Marie Heidingsfelder, Franziska Brodack*

## POSTERS

- S4726 **A contribution for Jewelry Design Teaching**  
*Claudia Regina Batista*
- S4730 **Analysis of Available Design Implementation Methods. A Study About Scarcity of Implementation Methods** *Ricardo Martins*
- S4734 **Anatomy of local government/design education collaboration.**  
*Adam Thorpe, Alison Prendiville, Lara Salinas, Sarah Rhodes*
- S4738 **Breathing Games: Promoting Respiratory Health Through Co-creation**  
*Maria Frangos, Fabio Balli*
- S4742 **Co–designing with plants. Degrading as an overlooked potential for interior aesthetics based on textile structures** *Svenja Keune*
- S4745 **Contemporary design. Variables and categories**  
*Vincenzo Maselli*
- S4748 **Design for the Smart Cities. Investigation about citizen’s needs and products to improve public places** *Lola Merino Sanjuán, Marina Puyuelo Cazorla, Mónica Val Fiel*
- S4751 **Design Lab: For Future Research**  
*Ahmet Başkan, Füsün Curaoğlu*
- S4754 **Designing for additive manufacturing technologies: a design research methodology** *Silvina Félix, Nuno Dias, Violeta Clemente*
- S4758 **Desirability in design for safety: Developing life jacket through creative problem solving method of TRIZ** *Shahin Matin, Mohammad hossein Namayandegi*
- S4761 **Exploring the Next Urban Condition**  
*Adam Fromme, Jeff Haase*
- S4765 **From Co-Working Places to New Education Places**  
*Füsün Curaoğlu, Duysal Demirbaş*

- S4768 **Image Management: The Contribution of Design**  
*Emílio Távora Vilar*
- S4771 **Modes. A Multi-sensory Media Experience for Stress Reduction**  
*Emily Verba Fischer, John Hebbeler*
- S4774 **MU.SA Method. Multimodal System Approach to the learning of the History of Design**  
*Isabella Patti, Roberta Vita*
- S4778 **Multidisciplinary approach for a new vision of urban requalification. Multi-scale strategies of social innovation, economic improvement and environmental sustainability practices. Multi-scale strategies of social innovation, economic improvement and envir** *Annamaria Bagaini, Zoe Balmas, Anna Koryakina, Anna Mangiatordi, Beatrice Jlenia Pesce, Caterina Reccia*
- S4781 **Resolving the OcuCheck: A Human-Centered Design Approach**  
*Matthew L. Bowman, Gina A. Taylor, Deana McDonagh, Leanne T. Labriola, Dipanjan Pan*
- S4784 **The “T” shaped designer expertise. The “reverse-T” shaped designer horizon**  
*Daniele Baratta*
- S4787 **The interface design for the application “Price My Job”**  
*Karolina Nunes Tolentino Costa, Claudia Regina Batista, Adhemar Maria do Valle Filho*
- S4791 **The Preemie Pod: A Wearable Incubator Designed for Premature Infants to Engage in Kangaroo Care** *Amanda Henderson, Deana McDonagh*
- S4794 **Threeing: Incorporating “Relational Circuits” into the Research Encounter**  
*Karl Julius Mendonca, Morgan Russell*
- S4796 **What is Next for Design Semiotics Research? Searching for epistemological answers in design outcomes** *Felipe Domingues, Salvatore Zingale, Dijon De Moraes*



# The Design Journal

An International Journal for All Aspects of Design

ISSN: 1460-6925 (Print) 1756-3062 (Online) Journal homepage: <http://www.tandfonline.com/loi/rfdj20>

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To cite this article: Barbara Stabellini, Chiara L. Remondino & Paolo Tamborrini (2017) Data Visualization Collection. How graphical representation can inspect and communicate sustainability through Systemic Design, The Design Journal, 20:sup1, S1673-S1681

To link to this article: <http://dx.doi.org/10.1080/14606925.2017.1352690>



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# Data Visualization Collection. How graphical representation can inspect and communicate sustainability through Systemic Design

Barbara Stabellini<sup>a\*</sup>, Chiara L. Remondino<sup>a\*\*</sup>, Paolo Tamborrini<sup>a\*\*\*</sup>

<sup>a</sup>Department of Architecture and Design, Politecnico di Torino

\*barbara.stabellini@polito.it

\*\*chiara.remondino@polito.it

\*\*\*paolo.tamborrini@polito.it

**Abstract:** Big data are totally changing the business rules, the society, as well as the perception of ourself. The need of a big data oriented culture is becoming essential for everything that has an informative assets. Furthermore, technological innovation offers products and features unique that can help to convey values and meanings, for the purpose of communication based on increasingly strong interaction between people. In a world where everything is consumed in a short time, it is important to turn information as visual as possible, making simple what is complex. The visualization becomes a medium for increasing cognitive perception of the beholder, easing reasoning and storing of the information represented, showing patterns and relationships, known or not, maybe not easily visible without the aid of a visual representation of information.

**Keywords:** sustainability, systemic design, data visualization, complexity

## 1. Introduction

We are living in an era of exponential increase in data production, collection and usage in different sector and in everyday life moments; for this reason the ability to collect, understand, communicate and make sense of information is going to be a very important skill. In terms of sustainability, data produced by environment, both infrastructures and individuals become tools for reading the society, quantifying its sustainable and unsustainable aspects; the study and the analysis of such data is fundamental to better understand what may be the future action strategies in order to improve environmental, economic and social sustainability.

The growing interconnection due to the digitalization of information and relations, as well as the exponential spread of data generated by things, people and organizations, represent a challenge and an opportunity to design new tools suitable to complex and changing environment in which we live. Therefore, it is essential to understand how it is possible to extract the most value from information, emphasizing the communicative potential contained in them (Cukier, 2013).

In a world where everything is consumed in a short time, it is important to turn information as visual as possible, making simple what is complex. Data visualization becomes a fundamental medium to explore phenomena, encouraging thinking, information memorization and interpretation; in other words make complex phenomena accessible through visual tool. The transformation from data to information, anyway, is not that simple, but is a continuous improvement path where data are collected, categorized and contextualized in a specific ecosystem.

Because of the importance of this transformation, the discipline and the role of the design become essential. Nevertheless, today many works that can be included within the topic of visualization of the data is often the result of the lack of design or of a design that does not take into account an overview. For this topic, design is often considered a surplus, but the discipline should find space right here, by filling this gap, positioning itself at the beginning of within the design whole process, not just at the end, so as to be able to offer a complete design in all its stages, and not a simple and common add-on.

Specifically, the purpose of our research is find positioning in the beginning of the decision procedure, offering an important contribution in the selection of the correct type of visualization graphics, adapting and shaping to better define guidelines to analyze and broadcast informations with a sustainable point of view.

In order to achieve the best result in term of comprehension and communication, it becomes essential the creation of a multidisciplinary team; indeed, data visualization cannot simply be defined as the representation of information in visual form, but it is a complex multidisciplinary field (Card, 1999), ranging from data mining to visual art, from psychology of perception to graphic and systemic design.

## 2. Collection

The use of charts, graphs, maps, diagrams, and tables is not new; this kind of representation accompanied us in the course of human evolution in dealing with the history and the socio-cultural contexts, the spaces and the organization of our knowledge based on models more and more suited to our way of life and the way in which we feed of information.

### 2.1 Environment as a context

Always, the greatest experimentations and monitoring has been conducted into the environment. For this reasons it becomes of fundamental importance to keep track of all that surround us and being able to understand data that environment offers.

This scenario allows to assume that environment is the context. The environment, in fact, produces data from space to people, both analogic and digital as well as the intersection of them and their correlation. This data become raw material, on one hand enabling a continuous transformation, and on the other hand encouraging always more new projects and visions, shared only if make visible.

Always, the weather conditions monitoring interest people, scientists, amateurs and national or international institutes. The meteorological data, be they collected by professionals, citizens or sensors and other technologies, has been, and currently is, fundamental in an attempt to forecast meteo and global climate changes. The sailor observation has been of vital importance to develop the first ocean current and wind maps. It is possible to see a particular and interesting series of data in the captains on board diaries of the East India Company ship. In 1709, the Rochester ship sailed away from Great Britain to China and its captain kept a detailed diary with ship sketch, wild animal

drawings and particular locations pictures, recording also all the information about position, path and meteo forecast. Today, the availability of huge amount of data, allows scientists to complete this work. Their images aren't only static maps, but are able to capture the dynamic nature of our global system. For example, the NASA visualization, shows oceanic currents thought satellite data collected between 2005 July and 2007 December, offering a dynamic overview, with significance and impact.

Also the healthcare field is strongly interested and involved in the data visualization; in fact, the graphic representation of the information is integral part for the healthcare improvement and the society well-being. History shows how sometimes the representation of harvested data could help to find causes and therapy diseases, as well as the tracking of infection rate and geographic distribution allow to monitor the epidemics diffusion or the identification of the local environmental factor that contribute to it. The most known and influential visualization in this topic is made by Dr. John Snow who tracked Soho deaths due to cholera in 1853 highlighting in a ghost map the water pumps of the area and crossing these data with the close deaths; in this way he could prove how epidemics didn't spread out by Thames, but by the water contaminated with human waste, thus strongly linking the healthcare question to the environmental one. Today, the healthcare data mapping continues to be very important, especially if connected with other demographic dataset: significative contribution in this regard is the work by the UK Chief Medical Officer that every year publishes an annual report in which there are mapped a huge number of mortality and morbidity, with the goal of offer a clear and objective overview on the national clinic situation.

Maps are a topic widely linked to mobility research, not only for what that concern path, travel indication and signs. The analysis and the visualization of tracked data by individuals, as by companies, can offer a particular reading of the around society. Since 1980, curious is the use of data from the UPS delivery company, which, through the initiative called ORION (On-Road Integrated Optimization and Navigation), started to track its vehicles, monitoring speed, direction, braking, and drive train performance. These data are not only used to monitor daily performance, but to redesign the route structures: this approach allows to reorganize the delivery path optimizing fuel consumption and, consequently, environmental carbon emission.

In the end, if we consider environment as the context, we can not refer to the energy issue, which is today one of the hottest topic, including consumption, discovery and implementation. The growing availability of energy data allows people to determines how they use them defining what is their impact on the environment, also linking these information with other dataset as public transport, technology, production.

## 2.2 Data visualization collection

In order to better collect, visualize and communicate data, for example as above mentioned, but not only limited at it, the literature reveals a lot of types of graphical representation from specific sectors (such as finance, economics, science or meteorology), but in terms of innovation and experimentation, all those forms can be applied in areas for which they were not designed, offering the expansion of the domains and purposes to which these practices are applied.

There are a lot of research which try to find the best way to classify graphics. One of the first characteristic of the existing taxonomies of graphs and images is the difference between functional or structural. Functional taxonomies focus on the intended use and purpose of the graphic material. In contrast, structural ones are derived from exemplar learning and focus on the form of the image placing more emphasis on emotions, rather than its content. In general this tendency arise from the distinction between the different experts's background, the firsts typically focused on statistics, computer science and engineering, while the second ones much more into graphic design and arts.

One of the most common and known example of functional classifications can be found in Edward Tufte. He identify four specific category in which classify graphics: the geographic representation through maps, the time-series, the graphic representation of events and phenomena which develop in space-time and the visualization of relations. (Tufte, 1983)

Also Heer, Bostock and Ogievetesky have put the emphasis on functionality in 2012; they proposed an articulated classification of graphics focusing on the experience of our times, and then paying attention on big data. Specifically, they identified four categories: time series, statistical distributions, maps, hierarchies and networks. (Heer, Bostock e Ogievetesky, 2013).

Different from a functional classification, Lohse et al. (Lohse, 1990; Lohse, 1994) classify visual representations using meaning and similarity between them. They identified six basic categories of visual representations: graphs, tables & time charts, maps & cartograms, diagram, networks, and icons.

In addition to taxonomies, there are a lot of catalog and table that collect the visualization methods. One of the most known book that collected and explain the use of each single type of representation is the manual of Harris (Harris, 1996). Another example is the Periodic Table of Visualization Methods (Lengler, 2007). This kind of classification aims to be less academic and draws on fields such as chemistry for his famous periodic table of elements. The periodic table is an interactive and prototypical example of Ben Shneiderman's visualization mantra of Overview first, zoom and filter, then details on demand. (Shneiderman, 1996). The visualization methods are categorized in data visualization, information visualization, concept visualization, metaphor visualization, strategy visualization and compound visualization. All graphics are then specified according task and interaction (overview, detail, overview and detail), the cognitive processes (convergent thinking, divergent thinking), and the represented information (structure, process).

Starting from the fundamental taxonomy defined by Tufte and the most common basic classification by Lohse et al., we collected 96 visualization graphics trying to offer a comprehensive collection. As it is possible to see in figure 1, there are many type of graphics, some of these unknown to many people, due to their specific field of use.

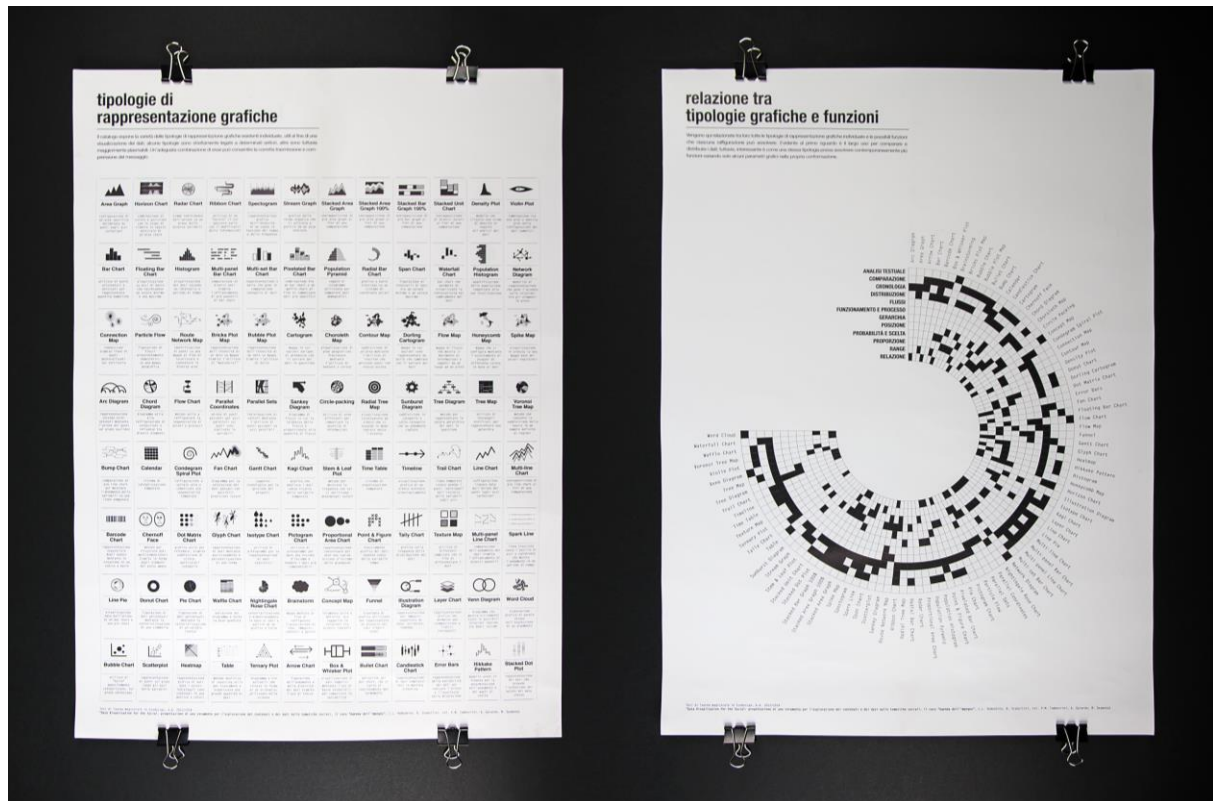


Figure 1. Collection of the types of representation and their functions.

Except for particular type of representations, the other ones can be used for different kind of data; nevertheless, it remains essential the right choice of the graphics in order to achieve the graphical excellence which consists of complex ideas communicated with clarity, precision, and efficiency. (Tufte, 1983; Cairo, 2013).

However, the importance of communication and the message that visualization itself should convey bring attention to move on the functions that these representations can perform. In order to allow this process, we identified twelve function to which a visualization have to perform, and we tried to relate each chart to each function defined: text analysis, comparison, timeline, distribution, flows, operation/process, hierarchy, location, probability/choice, proportion, range, relationship.

It's important to specify that each representation can be generally used to perform many functions, both in different projects and at simultaneously in an only-one visualization. An example can be the word cloud, a representation in which words that appear most frequently are larger and words that appear less frequently smaller, this is normally used for the text analysis, but at the same time it can highlight concepts by using dimension of the words, or put them in relation by space disposition.

### 3. Context and relations

Nevertheless, the identification of the right representation is only a part of the process. Data on their own do not say anything, they should be placed in context, correlated with each other or with other datasets to identify distributions, sizes and correlations; they have to be sorted and aggregated according to designed criteria.

To do so it becomes essential the analysis of the initial data and their inclusion in the context, properly related to each other and/or with other datasets to identify distributions, sizes and correlations, sorted and aggregated according to criteria to the search.

As Tufte wrote, context is essential to reply to the question “Compared to what?”. In fact, graphics must not quote data out of context and context is essential for graphical integrity. (Tufte, 1983)

Speaking of which, Wurman suggest that one of the main purpose of information representation is to help users avoid “the black hole between data and knowledge”; thanks to the relation with the context, unstructured information (reality and complexity), can be encoded in structured information and then knowledge and insights for a more conscious data driven decision making process, according to the DYKW hierarchies model (Data, Information, Knowledge, Wisdom).

Take into account context means also analyze users interested to the visualization, in order to offer a representation with a complexity level suitable to them and to answer the question “Do you know what it all means?”. In fact, basically there are two factors that influence the process of communication between the designer and the reference users: how the visualization used is well adapted to encode information on the nature of the story that you want to tell, and the background and knowledge of the reader about the argument represented. (Cairo, 2013).

Thus, information visualization is used to clarify and simplify information. It enables exploration of complex data, and can be used as a tool to persuade and convince observers of an idea by making information visible, highlighting the causes and effects of specific choices, comparing the different values and situations, showing the flow of a system and how it changes, analyzing the relations, distributing chaotic data into an ordered structure (Cairo, 2013; Shneiderman, 1996).

The design model used, known as Systemic Design (Bistagnino, 2011), pays attention to the organization, optimization and understanding of every single factor at play focusing at first on user requirements, then highlighting the best conditions and the most interesting facets to work on, while keeping an eye on their mutual relations. The focus moves from the simple sum of many elements towards a better understanding of the links between them and their strength, trying to balance functionality and aesthetics.

## 4. The role of design

To many people, information graphics are the images used in presentations throughout formal meetings or the graphs used in reports or newspaper articles. Many are used for these purposes; however, for each chart, graph, map, diagram, or table used in a presentation, there are others that are used for what that are called operational purposes. Representations for operational purposes are used by millions of people everyday for improving their efficiency and effectiveness, improving quality, solving problems, planning, teaching, training, monitoring processes, studying the geographic distribution of data, looking for trends and relationships, reviewing the status of projects, developing ideas, writing reports, analyzing census data, studying sales results, and tracking home finances. (Harris, 1996)

However, because of its historical roots in scientific reasoning, in academic research advanced information visualizations is often interpreted and characterized as scientific tools; the focus is therefore directed only to the functional requirements, not paying any attention to the aspects of user experience and graphic aesthetic.

In recent years, given the accessibility to the public of a great number of data sources as open data and environmental report, and the impact of that argument on the communication, the number of designers involved has increased, heavily impacting on the data visualization features. Information visualization is becoming more than a set of scientific tools to understand large data sets, but it is

emerging as a medium in its own right, with a wide range of expressive potential and its goal is to transform data into information and information into insight (Fiorina, 2004).

As in most other design-related fields, information visualization seeks to achieve a balance between the requirements of utility, soundness and attractiveness. Utility corresponds to the classic notions of functionality, usability, usefulness and other quantitative performance measures; these aspects generally define the effectiveness and the efficiency of the visualization. Soundness is concerned with reliability and robustness. Attractiveness refers to the aesthetics aspect: the appeal or beauty of a given solution; aesthetics does not limit itself to the visual form, but also includes aspects such as originality, innovation and user experience. (Moere, 2011)

If we take into account these requirements, the relation between design and information visualization becomes clear, and also becomes clear the importance of the design discipline during all the process: in fact, it is not an activity that can be added later.

But we want to underline the importance of the key background focused on sustainability. The goal of any data visualization design is to rethink constantly both the workflow and the language in order to increase knowledge and understanding to enable always more conscious behavior. It follows the importance of a network of actors involved in the project; networking is, in fact, considered essential for the growth of an ecosystem because of cooperation and inclusion processes help optimally managing the project and the goal pursuit.

## 5. Conclusions

Today, an increasing number of organizations and corporations, as well as single users or public administrations, are realizing that volume, velocity and variety of data require always more new applications. More than technology, though, they should adopt a different mind-set based upon data discovery and exploration; the visualization itself should be seen as a technology (Cairo, 2013) as an extension of ourselves. A good project has two main goals: it presents information and it allows users to explore and discover them; in other words data visualization is a tool for the designer to communicate with users and an instrument for users to analyze the reality presented.

In this way the role of the data visualization is to activate the attention and analysis process and generate order before people's brain try to do it. Thus, the visualization becomes a medium for increasing cognitive perception of the beholder, easing reasoning and storing of the information represented, showing patterns and relationships, known or not, maybe not easily visible without the aid of a visual representation of information.

On the role of the design is important to remember that the function constraints the form and that the graphical elegance is often found in simplicity of design and complexity of data; graphics should not simplify message. They should clarify them, highlight trend, discover pattern and show hidden reality.

The postmodern personality is fluid, complex and dynamic, and the needs of the people are always new; the different identities have different approaches to technology, communication and information. For these reasons, it becomes highly interesting to give the possibility of obtaining results by ensuring the personalization experience, with the aim of satisfying the different needs and driving the user to repeat his behavior.

In this context, information visualization can be a valuable tool to improve communication, to offer a higher level of information, but even to allow users a personalized path. All this can be applied to different contexts coming to assume the role of cultural analysis tool for discovering and

understanding data, decoding the complexity of contemporary society and abilitate always more new sustainable and innovative practices.

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About the Authors:

**Barbara Stabellini** is an ecodesigner interested in data visualization and innovation design, with a particular attention of the sustainability point of view. She is a PhD Candidate at Politecnico di Torino and co-founder of the Innovation Design Lab.

**Chiara L. Remondino** holds a MS in Ecodesign and is currently pursuing her PhD at the Politecnico di Torino. Her research is focused on big data, data visualization and sustainability. She obtained a Lagrange ISI Foundation fellowship on interaction in complex system. She co-founded the Innovation Design Lab.

**Paolo Tamborrini** is architect and Associate Professor of Design. Head of the Design School at Politecnico di Torino (Italy); founder and scientific coordinator of the Systemic Innovation Design Network (SyInDe). Editor about innovation design, eco-design and sustainability for the major design magazines.